A Multi-Modal System for Soccer Video Summarization

Graduation Project Progress Report 5

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Audio Version of la5sly

In this version the video summarization is based only on the audio feature i.e. when the audio level is high that gives an indication of an important event in the football match

Reason to make this version: the initial results of the main version showed that the audio feature is contributing significantly in the summarized final video so making a version with audio is worth the effort and would be much faster than the original version, with that said it’s not without its drawbacks

Advantages:

- Very less computations compared to the main version.
- Depends only on the Audio module and the shot boundary module but the main version has more modules to take into considerations.
- Much faster runtime

Disadvantages:

- The summarized output of this version is relatively longer in minutes than the main version as in many matches the audiences sometimes have loud voice while cheering even if it’s not really an important event in the game.
- The summarized video can get longer depending on audience and commentator attitude in every match.
- In rare situation, some important events are not included because the audio level is not larger than the audio threshold

Used Modules Details

Used modules: Audio, Shot Boundary

1. Audio module

Input: video clip

Output: times in video having volume level > 90% of the video volumes Algorithm:

1- Read video clip:

2- Extract audio from the video clip:

3- Get average volume of each 10 seconds

4- Get the difference between every two averages then detect the increases and decreases in volume:

5- Determine peaks indices of volumes:

6- Get peaks volumes:

7- Get Times of peaks having volume level > 90% [largest 10%]

2. Shot Boundary module

Input: two frames **Output:** cur or no cut

Algorithm:

1- Get color histograms of the two frames in RGB space

2- Calculate histogram intersection and correlation between the two histograms

3- If intersection >6 and correlation >5 then no cut

4- Divide the two frames into blocks, each block 150px x 150px and calculate intersection and correlation between individual blocks.

5- If intersection <4 and correlation <4 then block is 100% changed

6- If intersection >4 and correlation <4 then block is 75% changed

7- If intersection <4 and correlation >4 then block is 25% changed

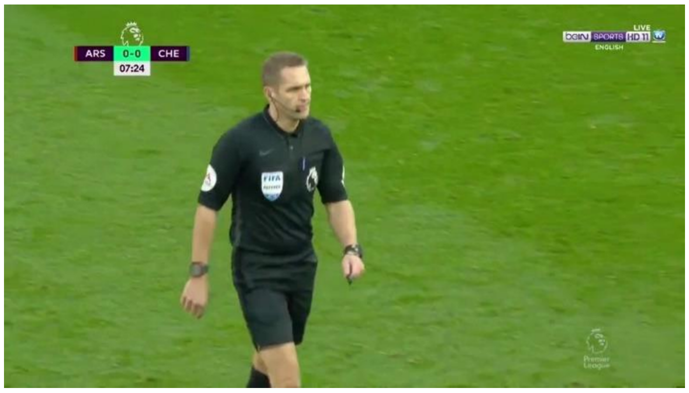
8- If none of the above conditions are met then the block is not changed

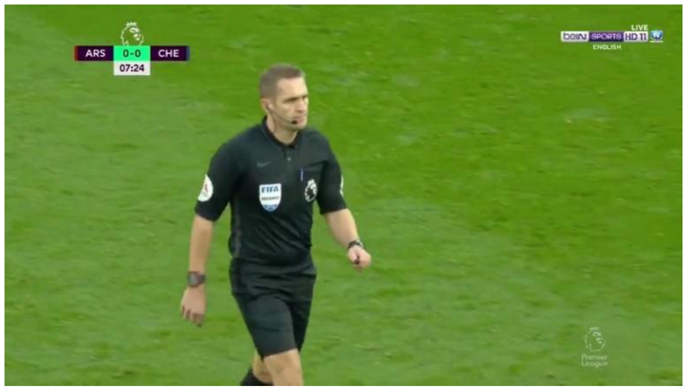
9- Count changed block and calculate percentage of changed blocks. 10- If percentage of changed blocks > 30% then Cut else no cut

Histogram intersection	Histogram correlation
$d(H_1, H_2) = \sum_I \min(H_1(I), H_2(I))$	$d(H_1, H_2) = \frac{\sum_I (H_1(I) - \bar{H}_1)(H_2(I) - \bar{H}_2)}{\sqrt{\sum_I (H_1(I) - \bar{H}_1)^2 \sum_I (H_2(I) - \bar{H}_2)^2}}$
This method simply compares, for each bin, the two values in each histogram, and keeps the minimum one. The similarity measure is then simply the sum of these minimum values. Consequently, two images having histograms with no colors in common would get an intersection value of 0, while two identical histograms would get a value equal to the total number of pixels.	is based on the normalized cross-correlation operator used in signal processing to measure the similarity between two signals, cross-correlation is a measure of similarity of two series as a function of the displacement of one relative to the other. This is also known as a sliding dot product or sliding inner-product.

For both *Correlation* and *Intersection* methods, the higher the metric, the more accurate the match. There are other metrics that we have tried but discarded, they will be discussed in the final project document

The two frames below are obviously consecutive frames from the same shot i.e. there is no cut.
that should be reflected in the values of histogram intersection and correlation

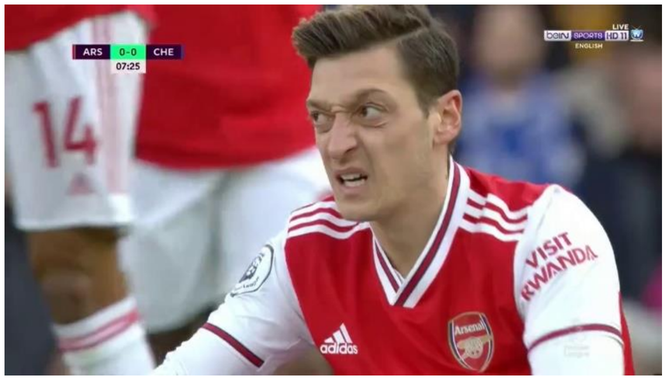
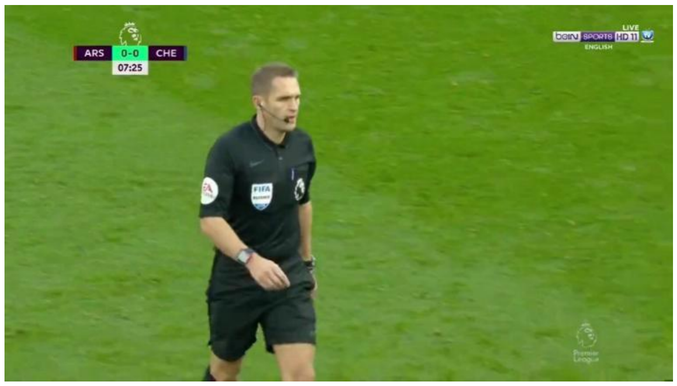




Histogram Intersection = 9.041203114076 78
Histogram correlation = 9.971235345958373

The values are higher than the thresholds mentioned in the above algorithm (the thresholds are based on trial and error) so no cut

Here is another example to fully explain how the shot boundary algorithm works.
These are also consecutive frames but there is a transition (cut) between them

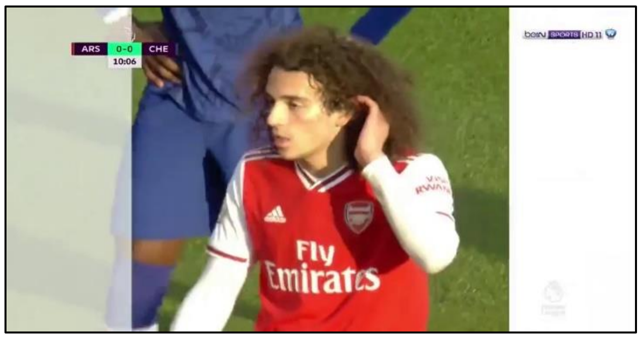
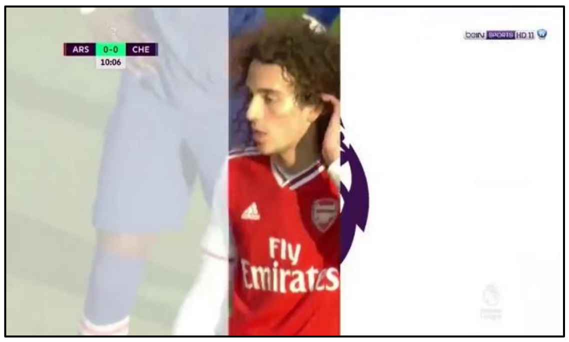
Histogram intersection = 0.24404063194742776
Histogram correlation = 0.002219072222348816

Both values are smaller than the thresholds so we perform step 4 of the algorithm in which dividing the two frames into blocks, each block 150px x 150px and calculate intersection and correlation between individual blocks then, according to the values of intersection and correlation of the blocks to consider whether that block is considered full changed or half changed or not changed at all.

Then, step 9 in which we count how many blocks have changed and calculate the percentage with respect to all block

In the above two frames the percentage of changed blocks is 100% i.e. all frame blocks have has changed so, there is a cut.

Another example to full demonstrate the importance of having two methods.
The following two frames are consecutive but in the midst of a logo transition (gradual transition)

Histogram intersection = 2.1293090697099615
Histogram correlation = 9.844120057485238

Here the two methods disagree, the intersection indicates that there are minor similarities in the two frames but the correlation indicates that that’s they are variations of each other i.e. the histogram is a shifted version of the other histogram for example.

So, we resort to the blocks process once again to determine if there is a cut or not. The percentage of changed block is 37% which makes sense because there are areas that didn’t change but according to the threshold this is still considered a cut and that is logical because it’s a logo transition.

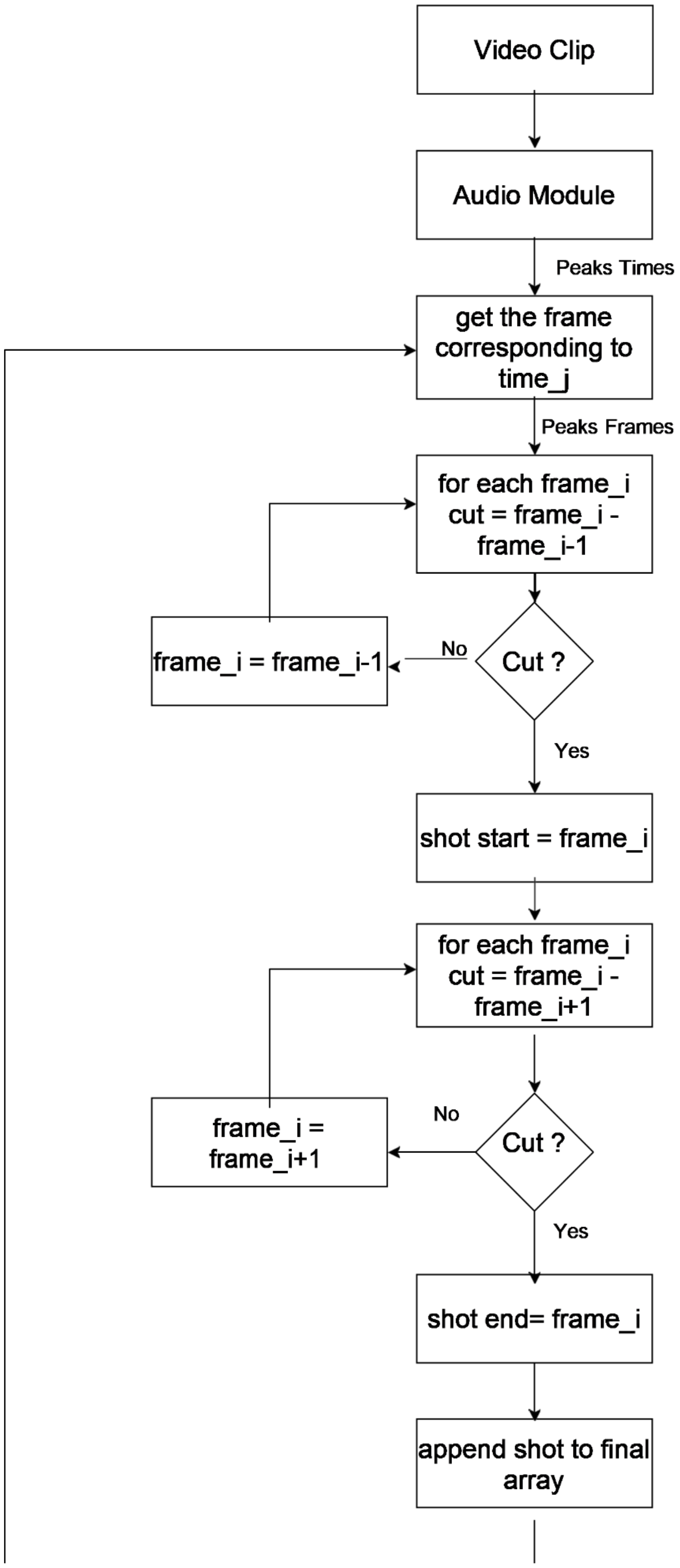
Audio Version Algorithm

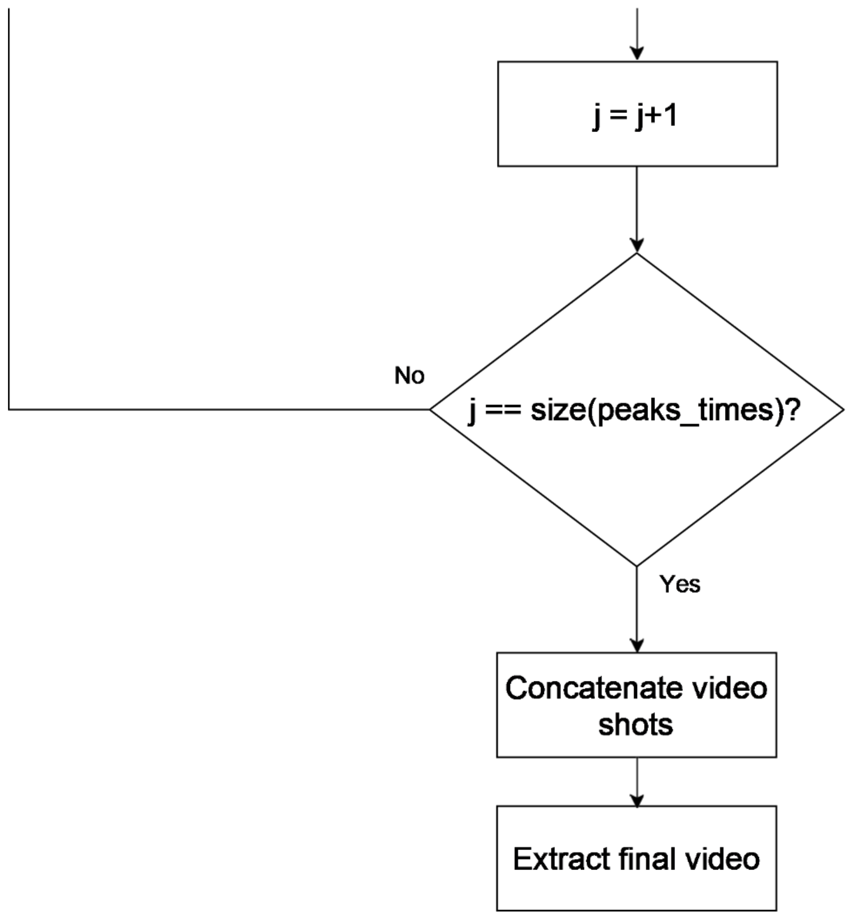
Input: Video Clip

Output: Summarized video clip

Algorithm:

```
1- Read video clip
2- Get Peaks times using Audio module, peaks [i…n]
3- For each peak time peaks[i], get its frame number
4- For each frame get its shot using the shot boundary module.
    1- Starting from this frame explore frames descending tell finding a shot
       cut
       = shot start
    2- Starting from this frame explore frames ascendingly tell finding a
       shot cut
       = shot end
    3- Having shot start and shot end, append this shot to the final array
5- Concatenate shots into one array
6- Extract the summarized video
```


Video Clip
Audio Module
Peaks Times
get the frame corresponding to time_j
Peaks Frames
for each frame_i cut = frame_i - frame_i-1
No
frame_i = frame_i-1
Cut ?
Yes
shot start = frame_i
for each frame_i cut = frame_i - frame_i+1
No
frame_i = frame_i+1
Cut ?
Yes
shot end= frame_i
append shot to final array


j = j+1
j == size(peaks_times)?
No
Yes
Concatenate video shots
Extract final video

Results

To evaluate each audio threshold level in different leagues we calculate a score based on the goals detected, the interesting events detected and also the length of the output summarized video, goals is the most interesting event so we multiply the ratio of the detected goals and total number of goals in the match by 0.6, for other interesting events we multiply it's ratio by 0.3 and we take the difference of 1 and ratio of length of output video and total length of video and multiply it by 0.1 to give a higher score for smaller length output video, then we add results to obtain the score.

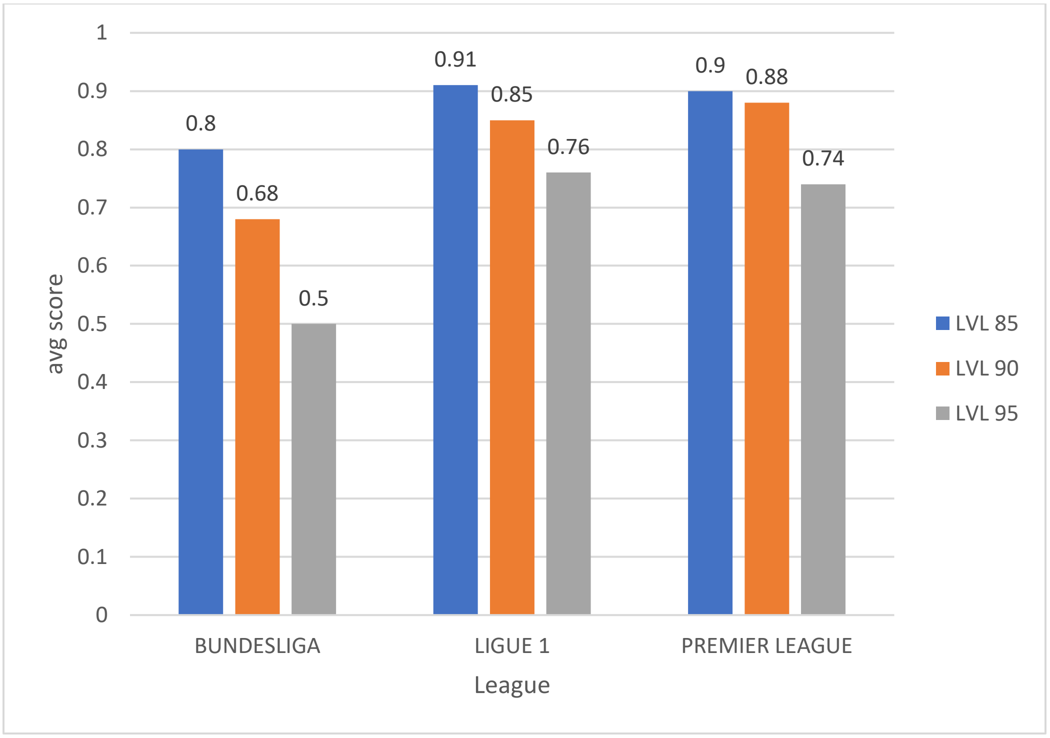
Equation:

$$\textbf{Score} = 0.6*\textbf{E1} + 0.3*\textbf{E2} + 0.1*(1 - \textbf{E3})$$

E1: no. Goals detected / total goals
E2: no. Of other interesting events detected / total no. Of events
E3: Length of output video / total length of video (=90)

League	Match	Audio Level Threshold	Output video Length in minutes	Goals Detected accuracy	Other events detection accuracy	Score
BUNDESLIGA	Fc Augsburg VS Dortmund	85	28:06	4/8	7/13	0.53
		90	10:03	3/8	3/13	0.38
		95	8:51	2/8	0/13	0.24
	Bayern Munich VS W. Bremen	85	16:06	6/7	16/16	0.9
		90	12:07	5/7	14/16	0.78
		95	8:28	4/7	11/16	0.64
	Bayer Leverkusen VS F. Dusseldorf	85	20:35	3/3	16/16	0.98
		90	15:50	3/3	10/16	0.87
		95	6:47	2/3	6/16	0.6
LIGUE 1	PSG VS Monaco	85	31:14	6/6	9/12	0.89
		90	23:46	6/6	10/12	0.92
		95	14:48	5/6	7/12	0.76

	Rennes VS Nantes	85	17:28	5/5	11/14	0.92
		90	12:38	4/5	8/14	0.74
		95	5:01	4/5	4/14	0.66
	PSG VS Marseille	85	26:27	4/4	8/10	0.91
		90	19:44	4/4	7/10	0.89
		95	8:35	4/4	6/10	0.87
PREMIER LEAGUE	Man. United VS Man. City	85	29:38	2/2	5/8	0.85
		90	21:42	2/2	4/8	0.83
		95	10:33	2/2	2/8	0.76
	Aston Villa VS Man. City	85	25:16	7/7	8/8	0.97
		90	17:01	7/7	7/8	0.94
		95	13:07	7/7	4/8	0.83
	Chelsea VS Arsenal	85	24:29	4/4	7/10	0.88
		90	18:04	4/4	6/10	0.86
		95	6:51	3/4	3/10	0.63



In the above chart, for each league an average score is calculated for each audio threshold level by adding their scores and divide it by total number of matches (=3).

Conclusion:

For most leagues we have tested level 85 threshold has the best results.
In premier league level 90 threshold has an average score very close to level 85 threshold so we can use it instead to reduce the length of the output summarized video.